Near-Field Characteristics of a Wideband Traveling-Wave Antenna Based on a Tapered Half-Mode Substrate-Integrated Waveguide

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Poster summary: This poster demonstrates a wideband omni-directional traveling-wave antenna based on a tapered half-mode substrate integrated waveguide (HMSIW) [1]. The antenna radiation mechanism is explained with the aid of figures of field distributions. In order to further verify the proposed radiation mechanism, in this investigation, the near-field characteristics of the antenna are measured and compared with simulation. The near-field measurement method using open-ended coaxial cable is described. The measurement and simulation results show a good correspondence which validates the measurement technique. The presented results show fundamental differences between the tapered HMSIW antenna and the traditional uniform leaky-wave antenna (LWA) [2]. Unlike the uniform LWA, the radiation of the tapered antenna mainly happens close to cut-off position, thus small radiating effective length and an omni-directional radiation pattern are obtained. It is worth mentioning that the analysis for the aperture field distribution of this type of antenna can be found in [3].

Key words: Half-mode substrate-integrated waveguide (HMSIW), near-field distribution, near-field measurement, wideband, traveling-wave antenna.

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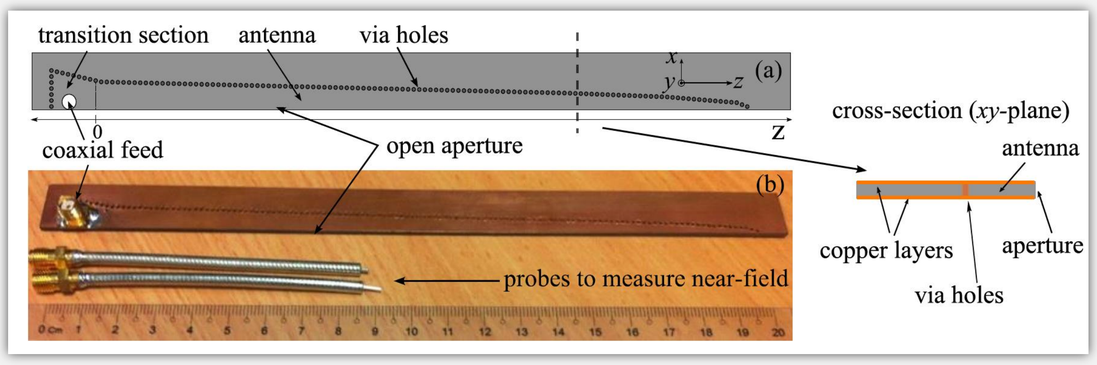
Abstract

The half-mode substrate-integrated waveguide (HMSIW) is created by cutting a SIW into a half. Due to the appearance of an open aperture, HMSIW has high radiation loss close to cut-off, which can be exploited to design antenna.

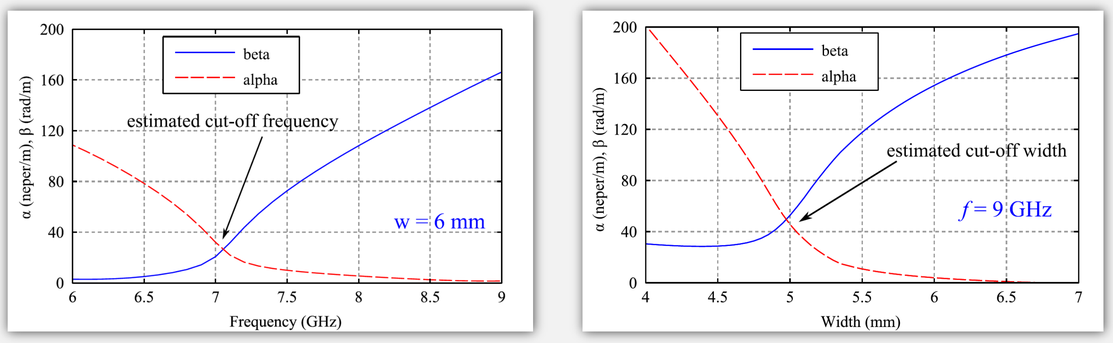
A travelling-wave antenna based on a **tapered** HMSIW has been proposed in [1] with some unique characteristics such as very wide bandwidth (6.7 to 16 GHz) and omni-directional radiation pattern with horizontal polarization.

This paper investigates the near-field distribution of this antenna to verify its guided-wave characteristics and radiation mechanism.



Radiation Mechanism

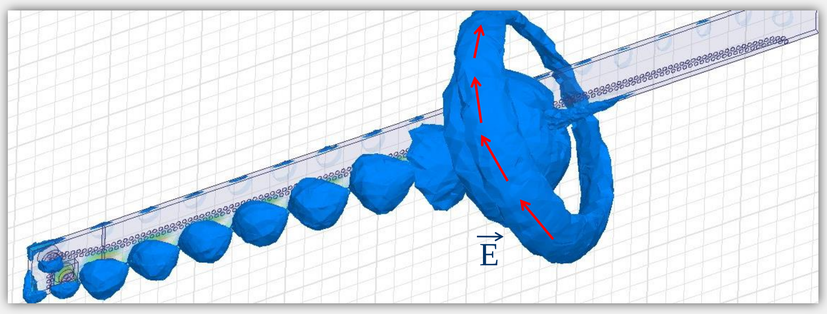
✓ The antenna exploits the radiation loss of the HMSIW close to its cut-off frequency.



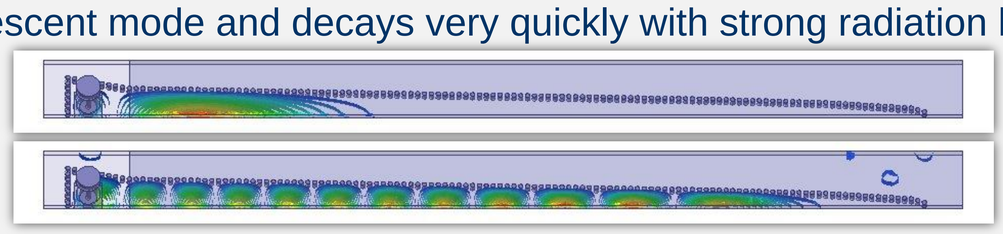
Wavenumber of a HMSIW at a constant width (left) and constant frequency (right).

✓ The excited wave travels along the tapered HMSIW until it reaches the position where the corresponding cut-off frequency is close to the operating frequency.

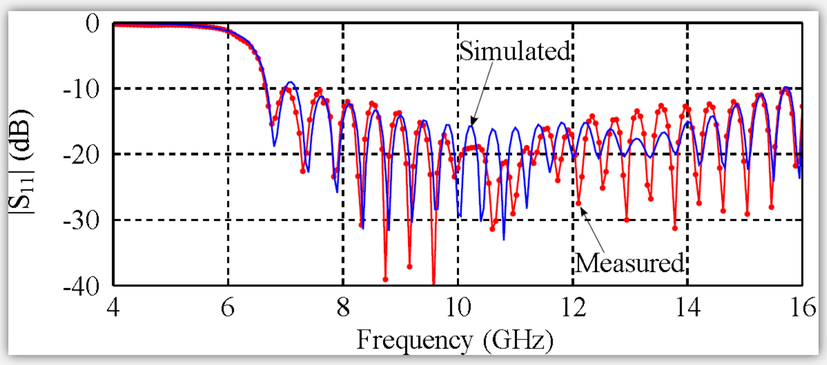
✓ In the vicinity of this position the power is radiated intensively due to the high radiation loss from the open aperture.



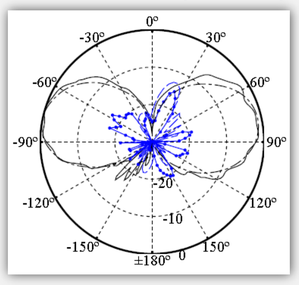
✓After the cut-off position, the wave transforms from a travelling to an evanescent mode and decays very quickly with strong radiation loss.



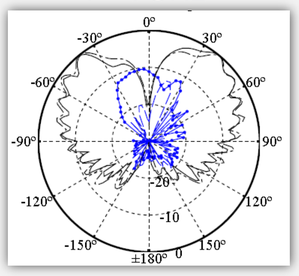
E-field distribution inside the substrate at f = 7 GHz (top) and 11.5 GHz (bottom).



Reflection coefficient (left) and radiation patterns of the antenna at two selected frequencies (right).

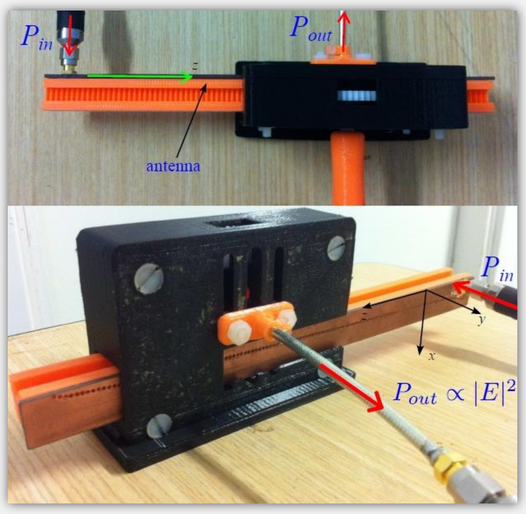


f = 7GHz



f = 11.5GHz

Near-Field Measurement Setup



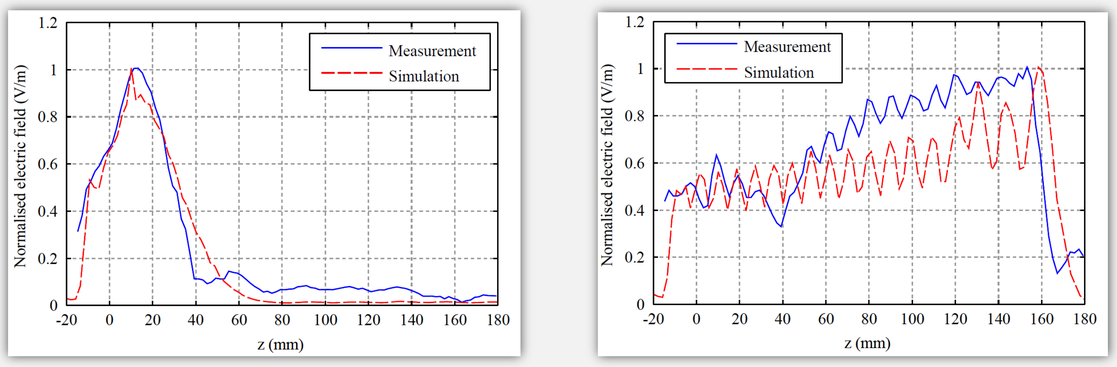
✓ An open-ended coaxial cable is used as field probe.

✓ A stand for the antenna and probes has been manufactured to perform reproducible measurements.

✓ The end of the inner conductor pin is fixed in *y*-direction.

✓ The measurement position in the *xz*-plane can be easily and accurately controlled by the antenna stand.

Simulation and Measurement Results



Magnitude of the electric field along the open aperture at f = 7 GHz (left) and 14 GHz (right).

Discussion

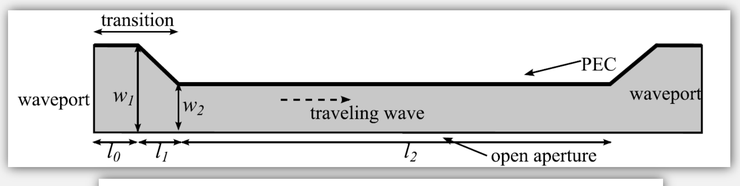
Field distribution:

✓ The field strength keeps increasing along the tapered antenna length until it reaches the frequency-dependent position of the cut-off.

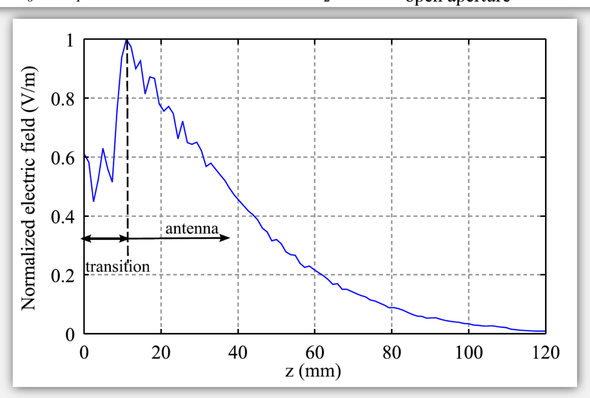
✓ This increase is due to the increase in the power density as the width is progressively tapered.

✓ After cut-off position, the wave decays very quickly towards zero.

Comparison with the uniform leaky-wave antenna in [2]:



A uniform HMSIW LWA similar to the one proposed in [2].



Field distribution along the uniform LWA (HFSS Simulation)

✓ For the uniform LWA, as the power is steadily radiated along the aperture, a smooth decaying curve is observed.

Conclusion

✓ The near-field distribution of a wideband travelling-wave HMSIW antenna has been measured and verified with simulations.

✓ The measurement validates the physical explanation for the antenna propagation characteristics and radiation mechanism proposed in [1].

✓ Fundamental difference in the field distribution with a uniform LWA is demonstrated.

✓ Detailed analysis for the near-field distribution can be found in [3].

References

[1] N. Nguyen-Trong, T. Kaufmann, and C. Fumeaux, "A wideband omni-directional horizontally polarized traveling-wave antenna based on half-mode substrate integrated waveguide," IEEE Antennas Wireless Propag. Lett., vol. 12, pp. 682–685, 2013.

[2] J. Xu, W. Hong, H. Tang, Z. Kuai, and K. Wu, "Half-mode substrate integrated waveguide (HMSIW) leaky-wave antenna for millimeter-wave applications," IEEE Antennas Wireless Propag. Lett., vol. 7, pp. 85 –88, 2008.

[3] N. Nguyen-Trong, T. Kaufmann, and C. Fumeaux, "A Semi-Analytical Solution of a Tapered Half-Mode Substrate-Integrated Waveguide with Application to Rapid Antenna Optimization," to be published in IEEE Trans. Antennas Propag. 2014.

Nghia Nguyen-Trong received a Bachelor degree with a first class Honour in electrical and electronic engineering from the University of Adelaide in 2013. He is currently working towards a PhD at the University of Adelaide with the Adelaide Applied Electromagnetic Group. His research interest includes applications based on substrate-integrated waveguide technology.

In 2011, he received an undergraduate scholarship from the IEEE MTT-s to work on a project about half-mode substrate-integrated waveguide, which resulted in a paper presented at the 2013 Asia-Pacific Microwave Conference (APMC). Based on his academic achievement, he received the Governor's International Student of the Year of South Australia award in 2012. He was one of the recipients of the best student paper award at the 2014 International workshop on Antenna Technology (iWAT).